

Influence of *Prunus* spp., Peach Cultivars, and Bark Damage on Oviposition Choices by the Lesser Peachtree Borer (Lepidoptera: Sesiidae)

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ABSTRACT An examination of oviposition choices by the lesser peachtree borer, *Synanthedon pictipes* (Grote and Robinson) (Lepidoptera: Sesiidae), showed that wounded peach, *Prunus persica* (L.) Batsch, bark was attractive to females for oviposition. Females responded to bark that was injured mechanically (e.g., hammer blows, knife cuts, pruning wounds), infested by lesser peachtree borer larvae or injured by disease. In fact, there was no difference in female oviposition response to knife cut wounds and knife cut wounds infested with lesser peachtree borer larvae. Oviposition on wounded bark from three different high chill peach cultivars was similar and strongly suggests that the narrow genetic base of high chill peach cultivars grown in the southeastern United States has little inherent resistance to the lesser peachtree borer. In stark contrast, when provided different *Prunus* spp., i.e., exotic peach and the native species *P. angustifolia* and *P. serotina*, the exotic peach was highly preferred for oviposition by the native lesser peachtree borer.

KEY WORDS *Synanthedon pictipes*, *Prunus persica*, *Prunus angustifolia*, *Prunus serotina*, Rosaceae

Lesser peachtree borer, *Synanthedon pictipes* (Grote and Robinson) (Lepidoptera: Sesiidae), is native to eastern North America, where it attacks various native *Prunus* spp. and is a pest of many exotic, cultivated *Prunus* spp. including cherry (*P. cerasus* (L.), peach (*P. persica* (L.) Batsch), and plum (*P. domestica* L., *P. avium* L., and *P. salicina* Lindley) (Girault 1907, Vogel and Neiswander 1933). Early research on *S. pictipes* attacking peach was published before the advent of low-cost, highly efficacious synthetic insecticides (Bailey 1879, Kellicott 1881, Quaintance 1906, Girault 1907, King 1917, Vogel and Neiswander 1933) and is similar to the current-day dialog regarding this pest attacking peach in the southeastern United States, where *S. pictipes* now causes considerable economic injury (Horton et al. 2000). Recent changes in pesticide availability for peach production likely have allowed some peach insect pests, e.g., San Jose scale [*Quadraspidiotus perniciosus* Comstock (Hemiptera: Diaspididae)], white peach scale [*Pseudaulacaspis pentagona* (Targioni-Tozzetti)] (Hemiptera: Diaspididae) and *S. pictipes*, to become major pests of economic concern to southeastern peach production (Horton et al. 2000).

From the early literature that focused on the bionomics of *S. pictipes*, we find that females generally oviposit in association with rough or damaged bark on trunks and scaffold limbs of host *Prunus* spp. trees

(King 1917). Bobb (1959) found no indication that *S. pictipes* larvae initiated injury and he could not establish larvae in the bark of young, nondamaged peach trees. Reed et al. (1988) reported that peach limbs with a diameter of <1 cm were not attractive for oviposition. Damaged bark suitable for oviposition can be attributed to natural (e.g., disease, winter injury, sun scald, and broken branches) and mechanical causes (King 1917). Later, research confirmed that disease-damaged bark wounds, i.e., *Leucostoma* (formerly *Cytospora*) cankers, were also attractive to females for oviposition (Swift 1986). The early research literature suggested that the exotic peach is preferred over native *Prunus* spp.; however, only anecdotal evidence has been provided in support of this observation (Girault 1907, King 1917, Vogel and Neiswander 1933). Reed et al. (1988) also reported higher oviposition on peach than the nonhosts apple and pear. Further evidence also suggests that bark wounds, regardless of the source, are attractive to *S. pictipes* females for oviposition (King 1917, Bobb 1959). Understanding oviposition site selection may facilitate better management of this pest.

Our objective was to determine the oviposition choice of *S. pictipes* presented exotic and native host species, different high chill peach cultivars, different types and ages of peach bark wounds, and larval-infested and noninfested wounds on peach bark.

Materials and Methods

Insects. A laboratory colony of *S. pictipes* was started by collecting late instars from peach trees near Byron,

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Table 1. *Prunus* spp. and peach cultivars used to assess oviposition choice of *S. pictipes* along with source and age of bark damage and average months used

Experiment	Host species—cultivar	Bark damage source	Age of bark wound when limb was cut	Mean \pm SE moths/cage
1 ^a	<i>P. persica</i>	Hammer	1 d	36.8 \pm 3.2
	<i>P. serotina</i>	Hammer	1 d	
	<i>P. angustifolia</i>	Hammer	1 d	
2 ^b	<i>P. persica</i> —GaLa	Knife cut	1 d	39.6 \pm 2.84
	<i>P. persica</i> —Red Globe	Knife cut	1 d	
	<i>P. persica</i> —Flameprince	Knife cut	1 d	
	Decoy	—	—	
3 ^b	<i>P. persica</i>	Hammer	1 d	69.8 \pm 0.22
	<i>P. persica</i>	No damage	—	
	Decoy	—	—	
4 ^a	<i>P. persica</i>	Larval damage	Natural wound of unknown age	47.7 \pm 10.3
	<i>P. persica</i>	No damage	—	
	Decoy	—	—	
5a ^a /5b ^b	<i>P. persica</i>	Knife cut with larval damage	7 d	62.9 \pm 7.7 ^c
	<i>P. persica</i>	Knife cut	7 d	
	Decoy	—	—	
6 ^b	<i>P. persica</i>	Pruned limb	1, 7, and 14 d	76.6 \pm 2.6
	<i>P. persica</i>	No damage	—	
	Decoy	—	—	
7 ^b	<i>P. persica</i>	Fungal gummosis	Natural wound of unknown age	71.8 \pm 2.0
	<i>P. persica</i>	No damage	—	
	Decoy	—	—	

^a Experiment replicated over time.^b Experiment replicated concurrently.^c Mean moths (\pm SE) per cage used during experiment 5a.^d Mean moths (\pm SE) per cage used during experiment 5b.

GA, and allowing them to complete development on green thinning apples cultivar Detroit Red. The colony was maintained on these green thinning apples similarly as described by Reed and Tromley (1985) with periodic introduction of field-collected larvae into the colony. After emergence, adults were placed into 122 by 56 by 60-cm screen cages and provided four 275-ml plastic feeding containers. Two of these containers were filled with 250 ml water and two with 250 ml 10% honey-water. Generic plastic scouring pads were inserted into each container to allow adults' proboscises access to the liquids while preventing bodily contact with them. A pair of containers, water and honey-water, were placed at each end of the cage.

Treatments. All choice experiments used cut test limbs (average length and diameter were 21.4 ± 0.5 and 5.7 ± 0.1 [SE] cm, respectively) from *Prunus* spp. Treatments consisted of *Prunus* spp. limbs that had damaged or undamaged bark and a decoy limb. Table 1 provides a listing of the *Prunus* spp. and cultivars used in each experiment, source of bark damage, and age of bark wounds before limbs were cut and taken to the laboratory. Limbs from black cherry (*Prunus serotina*) and Chickasaw plum (*P. angustifolia*) were collected from naturally occurring trees of unknown age at the USDA-ARS, Southeast Fruit and Tree Nut Research Laboratory, Byron, GA. Peach limbs were obtained from high chill, southeastern U.S. cultivars (Okie 1998) planted in two research orchards at the USDA-ARS, Southeast Fruit and Tree Nut Research Laboratory. Scaffold limbs of 8-yr-old peach trees, from an orchard that had not been treated with insecticides, were used in all but the second experiment (Table 1). Limbs for the second experiment were from

trees in a 14-yr-old orchard that was treated with fungicides and insecticides comparable to commercial orchards (Horton et al. 2007).

Mechanical damage to bark was done using a hammer or knife. Hammer damage was done with several blows to break ≈ 27 cm² of bark (experiments 1 and 3; Table 1). Knife damage was done with three connecting cuts (each 5.1 cm) made in bark to form an H (experiments 2 and 5; Table 1). Limb treatments with knife cuts + laboratory-reared *S. pictipes* larvae were infested immediately with larvae after cuts were made to bark. We used three late instars per wound (experiment 5; Table 1). Larvae for experiment 5 were obtained from our laboratory colony. When naturally occurring *S. pictipes*-infested wounds were used, infestation was confirmed by the presence of fresh frass that clearly indicated larval presence, thereby eliminating additional damage to the bark (i.e., mechanical damage from searching the wound; experiment 4; Table 1). Pruning wounds with an average diameter of 3.4 ± 0.2 (SE) cm were simulated by cutting secondary limbs from the treatment limbs (experiment 6; Table 1). Selection of pathogen-induced wounds was done by visual assessment of limbs infected with the fungal gummosis pathogen *Botryosphaeria dothidea* (Moug.; Fr.) Cos and De Not. Diseased limbs were chosen that had visually similar levels of bark wounding caused by *B. dothidea* (experiment 7; Table 1). A decoy limb, made to look like treatment limbs (as described below), was used in all but the first experiment. The decoy was made from a cylinder of hardware cloth with both ends covered in plastic wrap and the cylinder wrapped in cheese cloth.

Test limbs were cut from trees and taken to the laboratory, where both ends of the limb were tightly wrapped with three layers of a flexible plastic (Parafilm M; Pechiney Plastic Packaging, Menasha, WI). Limbs were entirely wrapped in four layers of cheese cloth. Because eggs of *S. pictipes* do not adhere to the substrate (T.E.C., unpublished data), the layered cheese cloth provided ample sites suitable for oviposition. In addition, the cheese cloth left a uniform surface over limbs, regardless of the treatments (i.e., damaged bark, undamaged bark or decoy), and visually made treatments highly similar. The cheese cloth was unwrapped from the limb and gently shaken, over a large piece of wax paper, to collect *S. pictipes* eggs. The few brown eggs that remained on the cheese cloth were easily seen against this white background.

Experiments. All choice experiments were conducted in screen cages with water and honey-water provided as previously described. Each experiment was replicated using a randomized complete block design where a single cage with adult moths and randomized treatments represented a block. However, whether an experiment was replicated over time or concurrently was dependent on the number of adult *S. pictipes* available from the laboratory colony. Experiments 1 and 4 were done using three or four replicates over time, respectively. Experiment 5 was done twice (each using three replicates): once when replication of treatments was done over time and then again when replication of treatments was done concurrently. Experiments 2, 3, 6, and 7 were each completed with three concurrent replicates.

Each replicate consisted of one cage, as described above, housing the treatments, water, and honey-water containers and moths. The cage floors were lined with brown paper. Treatment limbs were placed on white, plastic trays (54.0 by 27.5 by 3.3 cm; T.O. Plastics, Minneapolis, MN) with wounds facing upward. Trays, holding treatments, within a cage were placed 25 or 30 cm apart depending on whether three (experiments 1 and 3–7) or four (experiment 2) treatments were used, respectively. Moths were introduced to cages within 1–2 d after eclosion. When replications within an experiment were done concurrently, new moths were divided as equally as possible among cages. Because new moths were randomly introduced into cages and moths died during the experiments, the sex ratio in each replicate of an experiment was not determined. Similarly, age and mating status of moths in cages were not determined; moths remained in cages until they died, mating pairs were commonly observed, and the percentage hatch of eggs from experiments was determined. The mean (\pm SE) number of living moths used per replicate for each experiment is provided in Table 1. Experiments ran for 7 d, with egg collection done on Monday, Wednesday, and Friday. New cheese cloth was used to wrap treatments, including decoy limbs, after each egg collection.

Statistical Analyses. For each experiment, numbers of eggs recovered from each treatment in each replicate were converted to percentage data and arcsine

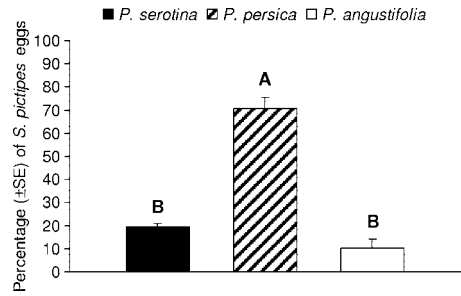


Fig. 1. Laboratory oviposition by the lesser peachtree borer, *S. pictipes*, when provided peach (*P. persica*), Chickasaw plum (*P. angustifolia*), and black cherry (*P. serotina*). Different letters above columns indicates significant difference between means ($P < 0.05$, LSD).

transformed (Zar 1999). Arcsine-transformed data were analyzed using a one-way analysis of variance (ANOVA). Mean separation was done using the least significant difference (LSD) test when $P < 0.05$ (SPSS 2005). Nontransformed means are presented.

Results

The mean (\pm SE) percentage of *S. pictipes* eggs that hatched (sampled from the different oviposition choice experiments) was $74.8 \pm 3.6\%$. The native *S. pictipes* laid significantly more eggs on the exotic peach than on either of the native *Prunus* spp. (i.e., black cherry or Chickasaw plum; $n = 2,789$ eggs; $F = 48.6$; $df = 2,8$; $P < 0.05$; Fig. 1). However, we did not detect that *S. pictipes* laid more eggs on any one of the three peach cultivars tested (i.e., Flameprince, GaLa, or Redglobe) or the decoy ($n = 3,704$ eggs; $F = 2.07$; $df = 3,11$; $P > 0.05$; Fig. 2). Bark that was physically damaged (i.e., as when struck with a hammer) garnered significantly more oviposition by *S. pictipes* compared with oviposition on the nondamaged bark and on the decoy treatment, and nondamaged bark had more oviposition than the decoy treatment ($n = 7,592$ eggs; $F = 1056.8$; $df = 2,8$; $P < 0.05$; Fig. 3). Similarly, bark that contained an active infestation of larval *S. pictipes* received more oviposition than non-



Fig. 2. Laboratory oviposition by the lesser peachtree borer, *S. pictipes*, when provided different high chill peach cultivars and a decoy treatment. Different letters above columns indicates significant difference between means ($P < 0.05$, LSD).

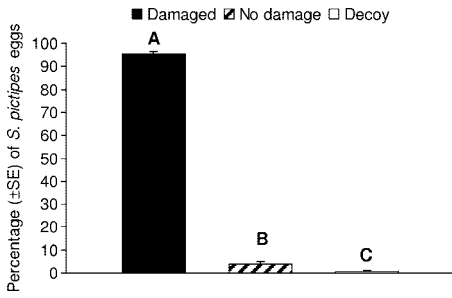


Fig. 3. Laboratory oviposition by the lesser peachtree borer, *S. pictipes*, when provided damaged and nondamaged peach bark. Different letters above columns indicates significant difference between means ($P < 0.05$, LSD).

wounded bark without a larval infestation and more than the decoy treatment ($n = 5,896$ eggs; $F = 134.5$; $df = 2,11$; $P < 0.05$; Fig. 4). When knife cuts were made in bark and the bark was either infested with larval *S. pictipes* or left with only the knife cuts, *S. pictipes* laid equivalent numbers of eggs on these two treatments but a significantly lower number of eggs on the decoy treatment both when the experiment was replicated over time ($n = 6,544$ eggs) and when replicated concurrently ($n = 14,093$ eggs; $F = 18.71$; $df = 2,8$; $P < 0.05$ and $F = 28.52$; $df = 2,8$; $P < 0.05$, respectively; Fig. 5a, b). Different aged pruning wounds, up to 14 d old at the beginning of the experiment, were similarly acceptable to *S. pictipes* as oviposition sites ($n = 5,810$ eggs; $F = 0.95$; $df = 2,8$; $P > 0.05$; Fig. 6). Bark exhibiting symptoms of *B. dothidea* infection elicited more oviposition than both the bark from the same tree not exhibiting *B. dothidea* infection and the decoy treatment ($n = 6,889$ eggs; $F = 37.86$; $df = 2,8$; $P < 0.05$; Fig. 7).

Discussion

Our experimental cages were large enough to allow unmated *S. pictipes* females to release their sex pheromone and attract males. Observation of mating pairs in cages was commonly observed. Additionally, $\approx 75\%$ of the sampled eggs hatched; thus, the numbers of

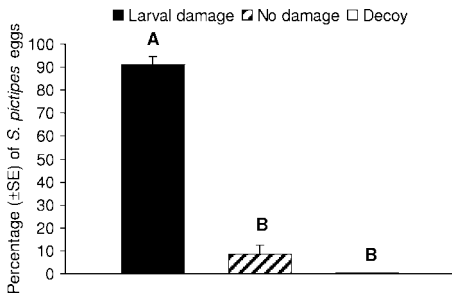


Fig. 4. Laboratory oviposition by the lesser peachtree borer, *S. pictipes*, when provided peach bark naturally-infested with *S. pictipes* larvae and nondamaged peach bark. Different letters above columns indicates significant difference between means ($P < 0.05$, LSD).

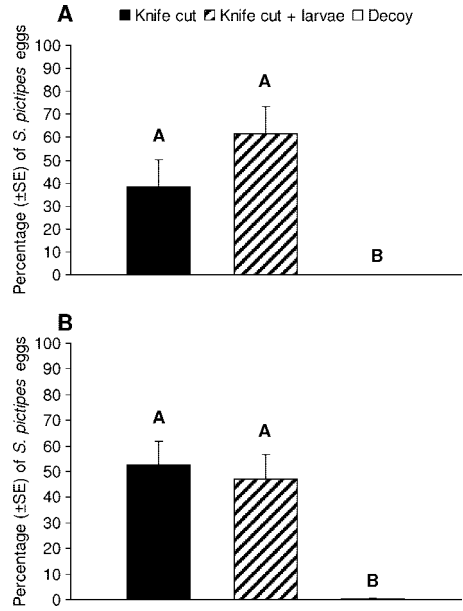


Fig. 5. Laboratory oviposition by the lesser peachtree borer, *S. pictipes*, when provided peach bark damaged with either knife cuts or knife cuts + *S. pictipes* larvae with replication over time (A) and concurrent replication (B). Different letters above columns indicates significant difference between means ($P < 0.05$, LSD).

moths used per cage was likely sufficient to ensure that most females were mated. It is also likely that the mated female test insects had ample room to move within the cages and make oviposition choices. Our method of preparing *Prunus* material for the oviposition experiments proved successful. For example, if our method of wrapping ends of cut limbs (i.e., another bark wound) with the flexible plastic did not work to severely inhibit the escape of plant volatiles, we would have expected more eggs on nondamaged bark treatments (e.g., Fig. 3).

Increased *S. pictipes* oviposition on the exotic peach over the native Chickasaw plum was not a surprise. Chickasaw plum is very abundant in central Georgia and is rarely observed with wounds infested by larval

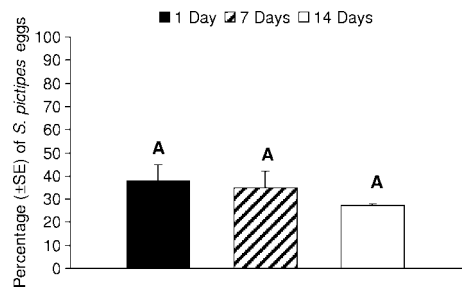


Fig. 6. Laboratory oviposition by the lesser peachtree borer, *S. pictipes*, when provided peach bark with pruning wounds of 1, 7, or 14 d old at the beginning of the 1-wk experiment. Different letters above columns indicates significant difference between means ($P < 0.05$, LSD).

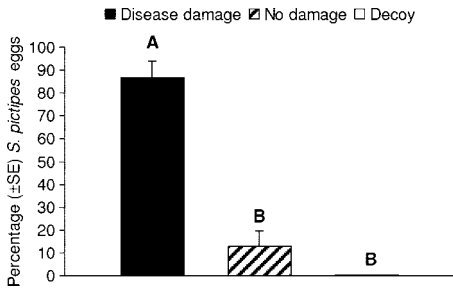


Fig. 7. Laboratory oviposition by the lesser peachtree borer, *S. pictipes*, when provided peach bark infected with the fungal gummosis pathogen *B. dothidea* and noninfected peach bark. Different letters above columns indicates significant difference between means ($P < 0.05$, LSD).

S. pictipes. Lack of infestation could be because of the fact that most Chickasaw plums exist in thickets (at the interface of fields and woodlots) (Radford et al. 1983), and many wounds on the small-diameter trunks and limbs may be too small to support complete larval development. However, in light of our experimental results and the lack of field observations on larval infestations, it could be that this species of *Prunus* is less attractive to *S. pictipes* than others. In contrast, the significantly lower oviposition recorded on the native black cherry was unexpected. Again, black cherry is common in woodlots across central Georgia, and it is quite common to find tree wounds infested by larval *S. pictipes* as Kellicott (1881) found them near Buffalo, NY. Thus, our results should not be used to indicate similar attractiveness of the two native species to *S. pictipes*. A separate test that excludes the highly attractive peach would need to be done to comment on whether natural infestations are more common on black cherry than on Chickasaw plum.

Among the three high chill peach cultivars tested, no difference was detected for the percentage of eggs per cultivar. The consanguinity of the selected peach cultivars is low; they have no common ancestors back three generations (Okie 1998; W. R. Okie, personal communication). Our results with only these three peach cultivars are by no means conclusive regarding the relative attractiveness of peach volatiles from all high chill, southeastern U.S. peach cultivars to *S. pictipes* for oviposition. However, Scorza et al. (1985) reported that an analysis of pedigrees of selected eastern U.S. peach cultivars indicated a high degree of inbreeding and coancestry that was caused by the narrow genetic base of parents continually drawn from the same gene pool. Research on the peachtree borer, *S. exitiosa* (Say), also showed no preference of this pest for tested peach cultivars (Brown et al. 1991). Thus, our results strongly suggest that inherent resistance of high chill, southeastern U.S. peach cultivars to *S. pictipes* is likely to be low. In support, Puterka et al. (1993) found that *Leucostoma* cankers on peach-almond hybrids were less abundant and had less *S. pictipes* infestation than cankers on peach.

Interestingly, it seems that *S. pictipes* seeks bark wounds, no matter the source, for oviposition, and this

is likely true of other Sesiidae. The dogwood borer, *Synanthedon scitula* Harris, is reported to attack dogwood trees (*Cornus florida* L.) with preexisting conditions (e.g., physical injury, diseased, low vigor, and sun scald) that make them susceptible to attack (Pless and Stanley 1967, Potter and Timmons 1981). King (1917) observed that external gum or sap flow influenced tree selection by *S. pictipes* females and commented that the sap odor attracts the female and further stimulates oviposition. In contrast, Bobb (1959) stated that old, uninjured trees with rough bark can be infested by *S. pictipes*, a scenario probably similar to infestation of burrknots on apple (*Malus domestica* Borkh.) by *S. scitula* and *S. myopaeformis* (Borkh.) (Bergh and Leskey 2003, Leskey and Bergh 2005, Ateyyat 2006). The previous statement by Bobb (1959) was further supported by Wiener and Norris (1982), who observed that female *S. pictipes* oviposited on roughened bark of *P. domestica* and not specifically in association with bark wounds. Given our current results, it is possible that scarce bark wounds and possibly more peach volatiles being released from those roughened areas of bark than elsewhere attracted *S. pictipes* for oviposition. Similarly, Derksen et al. (2007) reported that *S. exitiosa* oviposited in response to semiochemicals from the combination of peach gum and *S. exitiosa* larval frass.

Although we did not test all combinations of different types of wounds, when different types of wounds were compared, no difference in oviposition was detected. Oviposition on wounds would certainly allow hatching larvae ready access to food (i.e., exposed cambium) and shelter (i.e., damaged bark) and prevent them from having to search for openings in the bark as suggested by Wiener and Norris (1982). Because *S. pictipes* eggs do not adhere to the substrate, a majority of these eggs will fall when the substrate is jostled. In fact, this allowed us to easily remove eggs from cheesecloth onto wax paper for counting during experiments. Thus, without bark wounds, it is likely that *S. pictipes* oviposition would be low as would survival of neonates without ready access to food or shelter.

Commercial southeastern peach orchards are rife with bark wounds. Although most annual limb pruning in orchards is finished by late February, our current oviposition data indicate that the beginning of *S. pictipes* emergence by mid-March (T.E.C., unpublished data) could still provide oviposition sites for these early adults. Pruning later in the season to improve light penetration for fruit coloring and the removal of unwanted summer sprouts also provides oviposition sites. Limb breakage from a heavy crop load is common, providing further oviposition sites. Additionally, fungal gummosis can sometimes be quite common in orchards, resulting in a substantial number of sites for oviposition. Even low hanging limbs across row middles are repeatedly damaged by equipment moving through the orchards. These wound sources are suspected of adding to our current *S. pictipes* problems in southeastern U.S. peach orchards, especially since the discontinuation of methyl parathion use in 1998.

Although mating disruption has been used against this pest in other regions, both the high *S. pictipes* populations and the cost of product and manual labor for repeated, single-season applications of pheromone dispensers have hindered adoption of mating disruption in the southeast United States. Data from mating disruption demonstration orchards have not indicated the level of control deemed necessary (T.E.C., unpublished data). Additionally, label restrictions regarding chlorpyrifos application decrease the utility of this effective insecticide against *S. pictipes* populations that are active from March well into November. Therefore, short-term solutions for managing *S. pictipes* in commercial peach orchards should focus on efficacious replacements to methyl parathion. This would allow protection of orchards while developing long-term solutions directed toward host plant resistance (i.e., against both insects and disease), modifications in cultural practices (i.e., calendar dates for pruning or tree training systems that require fewer pruning cuts), and selection of cultivars with reduced pruning requirements.

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